PROCEEDINGS OF THE WORKSHOP ON:

THE FISHERIES OF KISORO MINOR LAKES: LAKE KAYUMBU, LAKE CHAHAFI, LAKE MULEHE AND LAKE MUTANDA

"TOWARDS SUSTAINABLE DEVELOPMENT AND MANAGEMENT OF THE FISHERIES RESOURCES OF KISORO MINOR LAKES".

VENUE:	**KISORO COUNCIL HALL**
HOSTS:	**FISHERIES RESOURCES RESEARCH INSTITUTE (FIRRI)** **P.O.BOX 343, JINJA-UGANDA.**
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PHYSICAL, CHEMICAL, ALGAL COMPOSITION AND PRIMARY PRODUCITON IN THE FOUR KISORO MINOR LAKES

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Introduction

The study was conducted between 1998 and 1999. Physical, chemical and biological factors of the water quality characteristics were collected and analysed.

Objective

The major objective for the study of minor lakes of Kisoro was to generate information required in formulation of development and management policies for enhancing increased and sustainable fish production.

Specific objective

To establish conditions that can promote increased and sustainable fish production.

Methodology

Using portable instruments, physical parameters (temperature, oxygen, PH, Conductivity were measured at different depths from surface to bottom of the water column from the water surface to the bottom. Water samples were collected using a verdom sampler at depth of 1m from the surface down to the bottom were for shallow lakes and 4m or above 30m were taken for deeper lakes. Water samples were taken to FIRRI laboratories for (nutrients, chlorophyll, and algal composition. Primary production was determined using the light and dark bottle method. Production was compared by differences in oxygen volume production between the light and dark bottles in 2 hr exposing time experiments on the lake.

Geographical setting

Kisoro district is in south western Uganda 29^0, 50 E, 1^0 8's close to the democratic Republic of Congo and the Republic of Rwanda at an altitude of 6000 ft (1830m) above sea level. The district has an area of 734 km2. About 94.5% is dry land (694km2), 3.7% (27.4km2) is open water, swamps make 1.75% (12.7km2) Figure 1. Lake Mutanda is joined to lake Mulehe through an approximately 2km long, River mucha at altitude of 5900-ft (1800m) above sea level. River Luhazenda flows from lake Bunyonyi to Lake Mutanda while R.Mkarara expands to Lake Edward. River Muhanga, Vuluga, Rugege, Mukiya flow into lake Mulehe.

Lake Chahafi and Kayumbu are close to Rwanda boarder and close to each other at an altitude of 6200ft (1890m) above sea level. Rivers Mukirimbi, Nyakagezi and Bukangano flows into Lake Kayumbu and Rivers Kabaya flows out of Lake Kayumbu and River Nyakariba empties its waters into Lake Chahafi. The Lands and

Survey Department, Entebbe has estimated the area covered by lakes as follows: L.Chahafi 1.0 km^2, L.Kayumbu 2.2 km^2, Mulehe 4.1 km^2 and Mutanda 26.4 km^2.

History of Kisoro Minor Lakes

These are crater lakes formed as result of volcanic activity, filling the crater long after the volcano had become extinct. Knowledge of the origin of a lake is of direct importance for the understanding of its morphology, its heat balance and its overall materials budget (Jorgensen and R.A Volleweider, 1988)

Catchment area description

Lake Kayumbu

The lake has a catchment composed of high mountains with steep slopes that are cultivated right up to the lake. A fringe of papyrus mats, farm land and cattle keeping zone extends all along. Crops such as beans, bananas, maize, sweet potatoes and sorghum are cultivated. Within the catchement there are some scanty human settlement, forests of eucalyptus trees and a lot of submerged water plants which are depicted in Appendix 1,2,3.

Lake Chahafi

Scanty papyrus and phragamytes surround the lake. Cultivation is done right up to the lake. The mountains are not very steep. The catchment area has fairly flat portions. Farming and cattle keeping is practised. There are few submerged plants like water lily, nuphir species. (Appendix 1,2,3).

Lake Mulehe

Has phragmites fringe. There are forests in the catchment area. Slopes are not very steep. Very little peasantry and cattle keeping is practised. No submerged plants were visible.

Lake Mutanda

Has frings of *phragmites* with farming and cattle keeping practised. The main crops grown are mainly bananas and sweet potatoes. There are forests in the catchment area with no submerged water plants. The lake has 17 islands and high mountains with very steep slopes. Cultivation is practiced right up to the lake some of the islands.

Results

Table 1. The range of physical and chemical parameters of the four Kisoro minor lakes

Lake	Temp O^c	DO mg/l	PH	Cond us/c	Trans (M)
Kayumbu	14 – 22.9	1.3 – 6.8	7.4 – 9.0	87 – 218	0.5 – 0.9
Chahafi	17.1 – 24	0.9 – 11.6	7.2 – 8.0	122 – 267	0.6 – 1.0
Mulehe	17.4 – 22	2.2 – 14.8	7.1 – 8.8	112 – 260	0.4 – 0.5
Mutanda	19.2 - 22	1.1 – 6.6	7.7 – 8.8	112 – 241	2.84

DO = Dissolved Oxygen

Temperature

The four lakes had water temperature range of (14 – 24°C) Figure 12. These temperatures were low. Fish have a range of temperature considered as the upper and lower range where they can survive comfortably. When temperature go beyond this optimal range it could cause stress on the fish, abnormal metabolism and poor growth. This results in low resistance to diseases. *Oreochromis niloticus* can tolerate water temperature in the range of 14°C to 42°C. An ideal temperature for fish survival is 25-30°C (Chervinski 1982).

Dissolved oxygen levels:

Oxygen is derived from photosynthesis and diffusion from the atmosphere (wind aeration). Lack of oxygen results in poor growth and outbreak of diseases. Tilapia requires oxygen in the range of 1-3mg/1 but 5mg/1 is ideal for growth. All the four lakes were observed to have low oxygen values at the bottom falling to below 2mg/L. (Figure 4). The anoxic conditions exist in all the lakes probably throughout the year as it is unlikely that there is a chance for these lakes to fully mix because of being shielded by high mountains from strong winds. Low oxygen levels are made worse by aquatic plants which cut off light from phytoplankton which are largely responsible for producing oxygen by photosynthetic process. In the upper layers however, oxygen values are as high as 14mg/l.Lake Mulehe exhibited the highest oxygen production. This is explained by high chlorophyll values 165 ug/1 (Figure 2).

Chemistry of the Lakes

The Chemical Characteristics of the lakes are shown in table 2

Table 2: The Chemical Characteristics of the Kisoro Lakes

Chemistry	Kayumbu	Chahafi	Mulehe	Mutanda
NH4	1.6-52.6	0-43.3	0-44.1	5.9-36
NO2	0-5.3	0-7.9	0-4.6	0-4.4
NO3	0-21	0-22.2	0-4.4	0-43
SRP	1.7-7.3	2.8-16.9	1.4-13.6	1.7-12
TDP	7.1-37	9-60.7	6.1-27.5	9.3-26
SI	3269-5248	3278-9947	2212-9302	3122-7040
ALK	49	36.6	67-72	76.6-72
CHL(a)	8.6-77.1	9-63.9	39.6-165	2.09-43.1

NH4 = Ammonium nitrogen, NO2 = Nitrite nitrogen,NO3 = Nitrate nitrogen, SRP = Soluble Reactive Phosphorus, TDP = Total Dissolved Phosphorus, SI = Soluble Silicon, ALK = Alkalinity, CHL (a) = Chlorophyll.

Discussion

Nitrogen and phosphorus are significant for the productivity of lakes. Phosphorus is commonly the limiting factor for productivity due to its small supply. Silica is required for the body material of some phytoplankton species (diatoms).

Nutrients supply to these lakes is either from precipitation (rainfall) or wash down from catchement area through rivers feeding into lakes or through internal cycling of nutrient regeneration from the system. Looking at the nutrient data for the month of March 2 (rainy season) (Figures 5,6,7,10,11 and 13) the increase in concentrations was due to rainfall and loading from the catchment through rivers.

Nitrogen levels (nitrates) are very low in most cases no quantities detected at all (Figure 7). This is an indication that nitrogen is deficient and as a result nitrogen fixing phytoplankton became dominant to fix nitrogen which is on demand in the system (refer to algal composition Table 3). This is further explained by lowest transparency value of 0.43. Transparency is affected by standing phytoplankton, which is responsible for high chlorophyll values (Figures 2,9).

Lakes Kayumbu and Chahafi have similar oxygen production potentials (Figure 2 and 4). In the upper layers they have sufficient oxygen in the first 10m upper layers. There is high production in the upper layers. This is explained by high transparency values (2.84m) Figure 9. at the lower depth. However, light is a limiting factor to photosynthesis process and this is why there is low oxygen values less 1.5mg/1.

PH indicates the [H+] which determines whether the water is acidic or alkaline. The ideal ph for warm water culture is 6.5 – 9.0 At this pH fish thrive well and grow fast. PH 4 to 5 no reproduction. 5 to 6.5 slow growth. The four lakes show a PH range of 7.13 – 9.09 (Figure 8). This is quite ideal for fish growth and reproduction.

Conductivity

The specific conductivity is closely proportional to concentrations of the major ions ($Ca^{2+}Mg^{2+}Na^{2+}K^{2+}$) and changes in conductivity reflect proportional changes in ionic concentrations. Three major mechanisms control globally the conductivity of surface waters: weathering of rocks, atmospheric precipitation and the relation between precipitation & evaporation.

Lake Chahafi had the highest conductivity 267 us/cm during the rainy season of March compared to Kayumbu which had the lowest 87 us/cm in the dry season (Figure 3). The highest conductivity during the rainy season is due to wash down from the catchement area into the lakes. The low conductivity in the dry season is due to evaporation effects. There is no direct effect of conductivity on fish growth or health. Conductivity however has the role in available nutrient levels as it may be bound by the major ions ($Ca^{2+}Mg^{2+}Na^{2+}K^{2+}$).

Phosphorus was highest in chahafi (2.8 – 16.9) and lowest in Kayumbu (1.7-7.3 ug/I) (Table 2). It is apparent that phosphorus loading from the catchemnt area is not a serious problem since phosphorus is on demand by crops in the intensively cultivated catchement area.

Chahafi showed the highest value of silica 3278 – 9947ug/l (Table 2). High silica concentrations promotes growth of diatoms in lake Chahafi. Phytoplankton feeding fish would have a chance of food availability.

Algal composition of Kisoro minor lakes

Table 3 shows the algae observed in the Kisoro minor lakes

Algal Composition of Kisoro lakes

% algal composition	Kayumbu	Chahafi	Mulehe	Mutanda
Cynobacteria	57.7	47.2	80.9	60.0
Chlorophyta	32.8	23.3	6.0	18.5
Bacillariophyta	13.5	28.8	13.0	28.4

Cynobacteria algae dominated in all the four lakes (Table 4, Figure 3). This was followed by *Chlorophyta* in Lake Kayumbu while *Bacillariophyta* was second in dominance in L. Chahafi, Mulehe and Mutanda. It is therefore noted that fish feeding directly on phytoplankton have generally *Cynobacteria* group of algae available in their stomachs. It also implies that zooplanktons which prefer to eat *Cyanobacteria* algae would be dominant.

Lake Chahafi was dominated by *Chrysophtis* and the most common one was *Cyclotella*. This was followed by *Cynobacteria* with *Lyngibya* being common. In L. Kayumbu *Cynobacteria* with *Microcystis* was the most dominant. *Lyngibya* and *Microsystis* dominated in L. Mutanda. L. Mulehe was dominated by *Cynobacteria* and chlorophyll with *Microcystis*. L. Kayumbu, Mulehe and Mutanda were dominated by *Cynobacteria* group of algae. L. Chahafi however was dominated by a different group of algae *Chrysophytis* followed by *Cynobacteria.*

Conclusion and Management Recommendations

The lowest lake water temperatures was 14°C and highest 24oC. This was far below Lake Victoria temperatures of 24 – 26 °C. Low temperatures affect growth of fish and reproduction. Fish which can tolerate low temperatures will have to be stocked and continuous restocking has to be done since there will be low reproduction and therefore low recruitment in the system. Low temperatures also affect growth of phytoplankton and other organisms, which form food items for fish. The stocking densities have to be determined if stocks have to be sustained by the natural food supply.

Oxygen levels

The low Oxygen levels less than 2mg/l at the bottom in L.Chahafi (5m depth) and at depths between 20 – 40M in L.Mutanda is a problem. Low oxygen supply affects the health of the fish. This low oxygen is being caused by submerged water plants which cut off light necessary for photosynthesis in Lakes Kayumbu and Chahafi. The water plants thrive because of nutrient regeneration from the bottom of the lakes. Mirror carp can effectively control aquatic weed in lakes because they are active bottom feeders and are constantly foraging deep into the mud in search of food. As they are naturally both large and very strong fish, this behaviour would results in aquatic plants being continually uprooted, which proves fatal to other species. Common.carp would also directly consume the newly sprouting shoots of many plants as a normal part of their omnivorous diet. The process of feeding which can be active in warm weather results in the disturbance of large volume of mud/silt which become suspended, and hence cloud the water resulting in nutrient enrichment from the bottom of the lakes Kayumbu and Chahafi which were stocked with common carp in 1960. This explains why there are many submerged plants in these lakes.

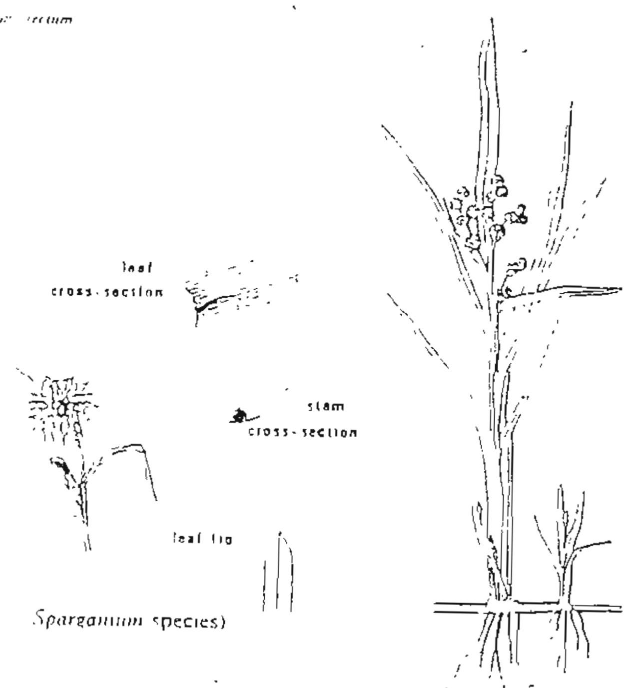
Nutrient enrichment

Poor farming practices are responsible for degrading the environment. It was observed that all the four lakes, cultivation was done right up to the lake. There was no buffering zone between the lake and the land. The ecotone zone had been cleared nutrients enter the lake direct which would otherwise be filtered by wetland zone.
As a management strategy ,the community should be sensitised about the farming practices, endeavour to restore the lake wetland by planting papyrus, vosssia and fragamytes by the lakeside leaving 50M strip uncultivated.

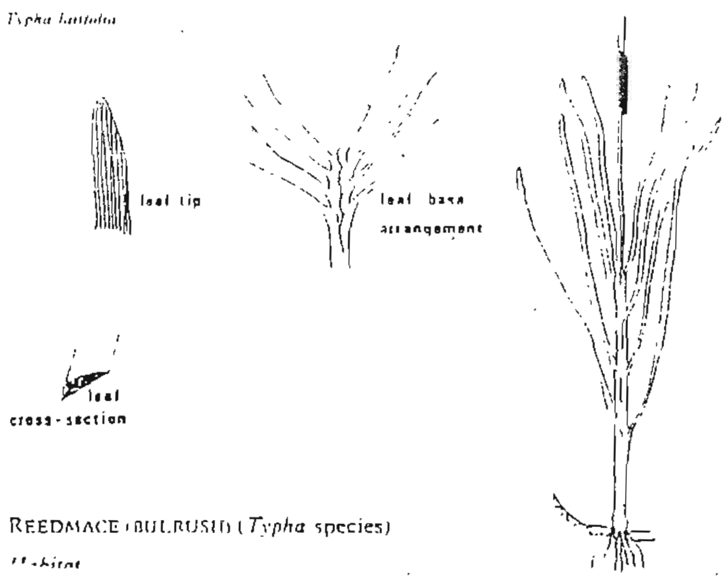
In Lake Mulehe, algal blooms were common. This was due to nutrient enrichment from rivers feeding the lake. Fish which feed on plankton or zooplankton would do very well in this lake. The algal bloom in extreme cases would become so intense as to prevent light from penetrating a few centimetres below the surface. Light limitation would affect photosynthesis which would lead to low oxygen levels.

Lake Kayumbu and Chahafi had a problem of submerged weeds. Common carp can control the weeds if introduced at very high stocking densities of 2500 fish/ha, Common carp enjoys a long life of 15 yrs +.

Lake Mutanda has nutrient input via River Mucha from L.Mulehe. Low oxygen levels at 20M depth and below reduces available space for fish to occupy. The upper layers however receive plenty of light and are highly productive. High Oxygen levels in the upper layers would be distributed in the water column if this lake had strong winds to mix the water. The lake is heavily shaded so it is unlikely that the lake ever mixes completely. The inshore areas are very productive and would support a variety of fish species.



Sparganium species)



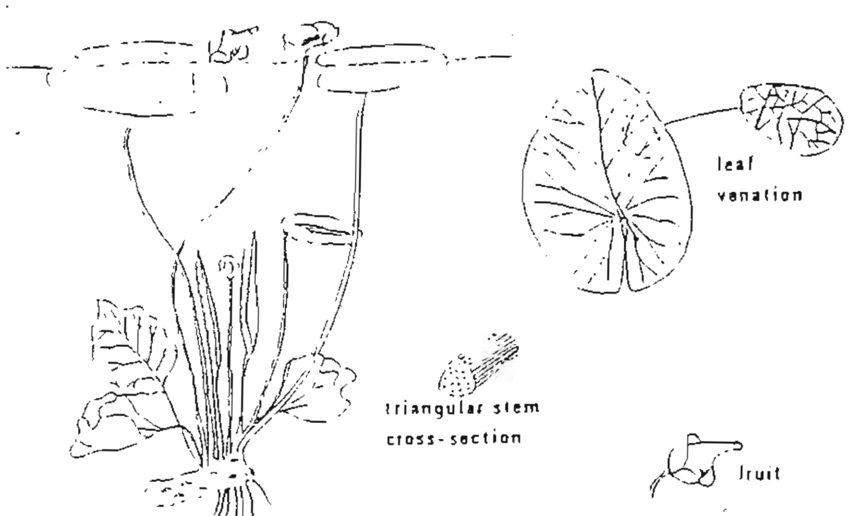
Emergent plants

REEDMACE (BULRUSH) (*Typha* species)

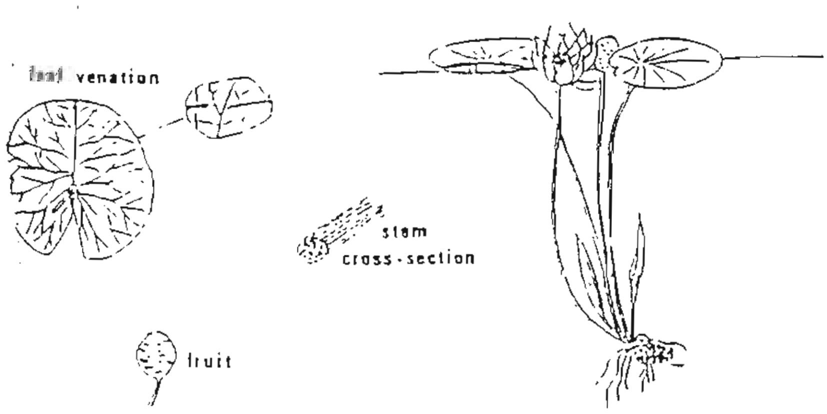
bogs. Can form extensive

Appendix 2

Floating-leaved plants

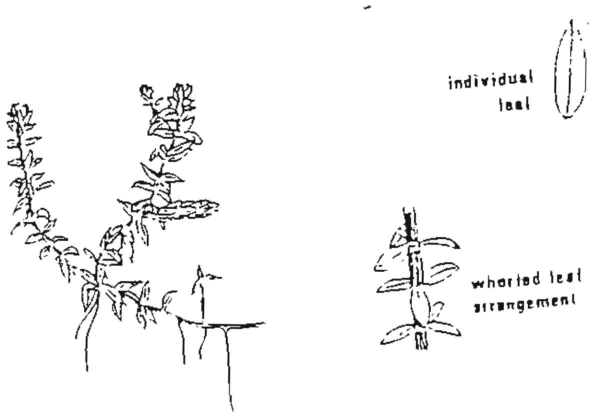


Nuphar lutea

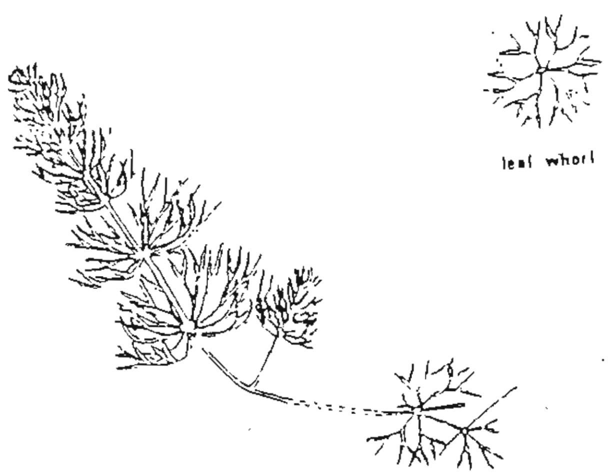


Nymphaea alba

Appendix 3



Elodea canadensis



Ceratophyllum demersum

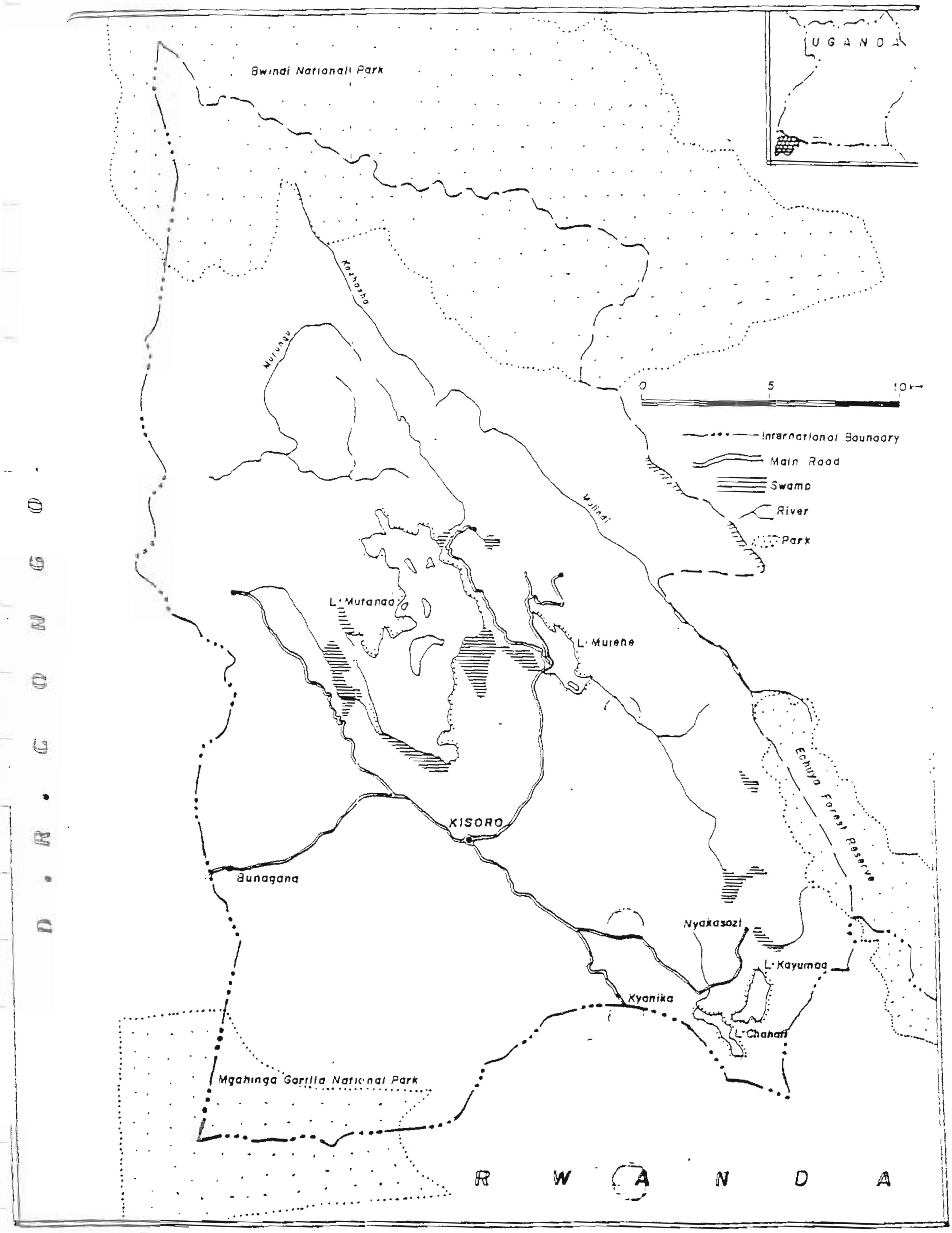


Figure 1 A map of Kisoro district showing the position of the four minor lakes.

add rivers mentioned in text

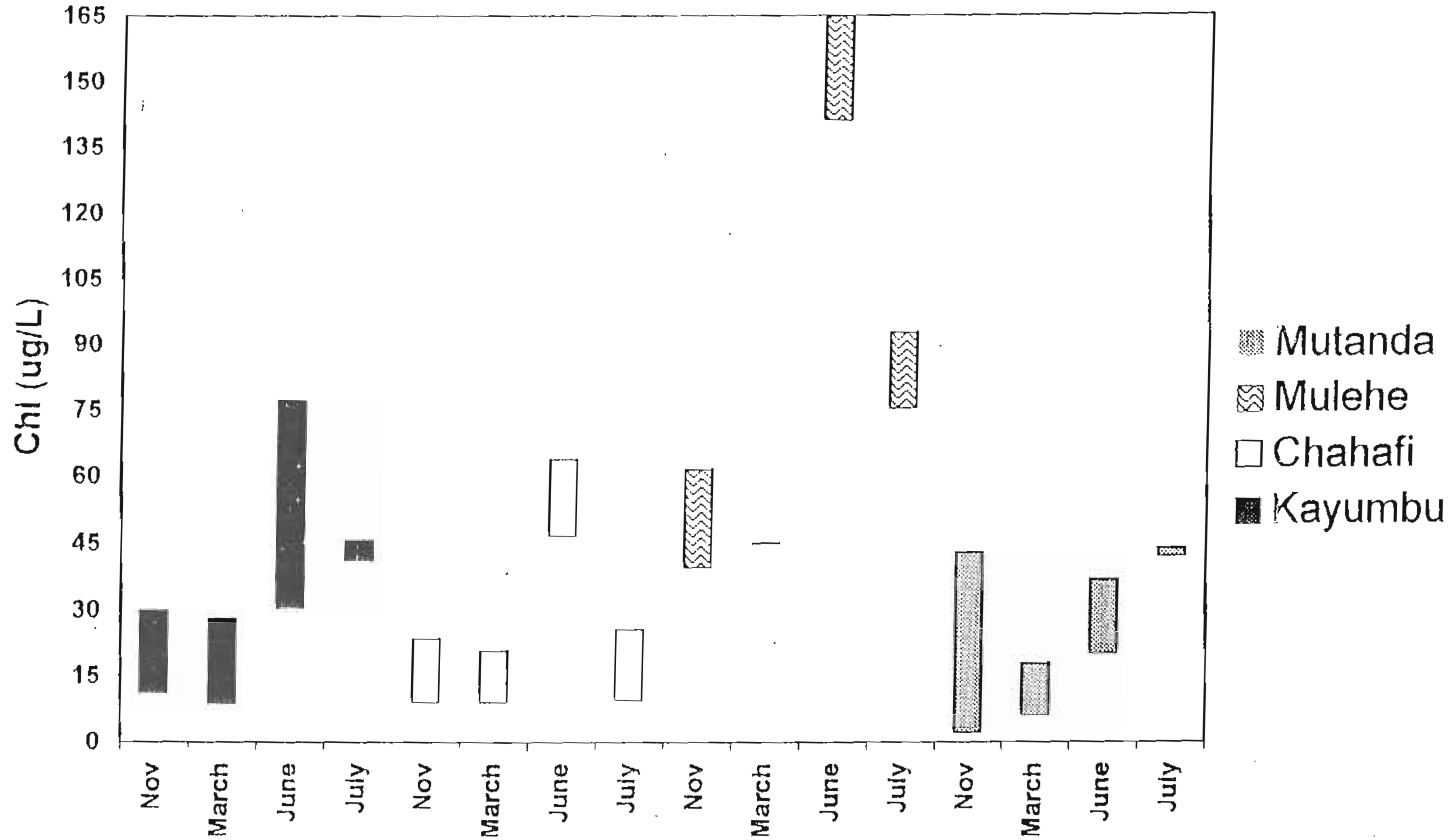


Figure 2: Chlorophyll Conc. (ug/L) for Kisoro Minor Lakes
Period: Nov 98 - July 99

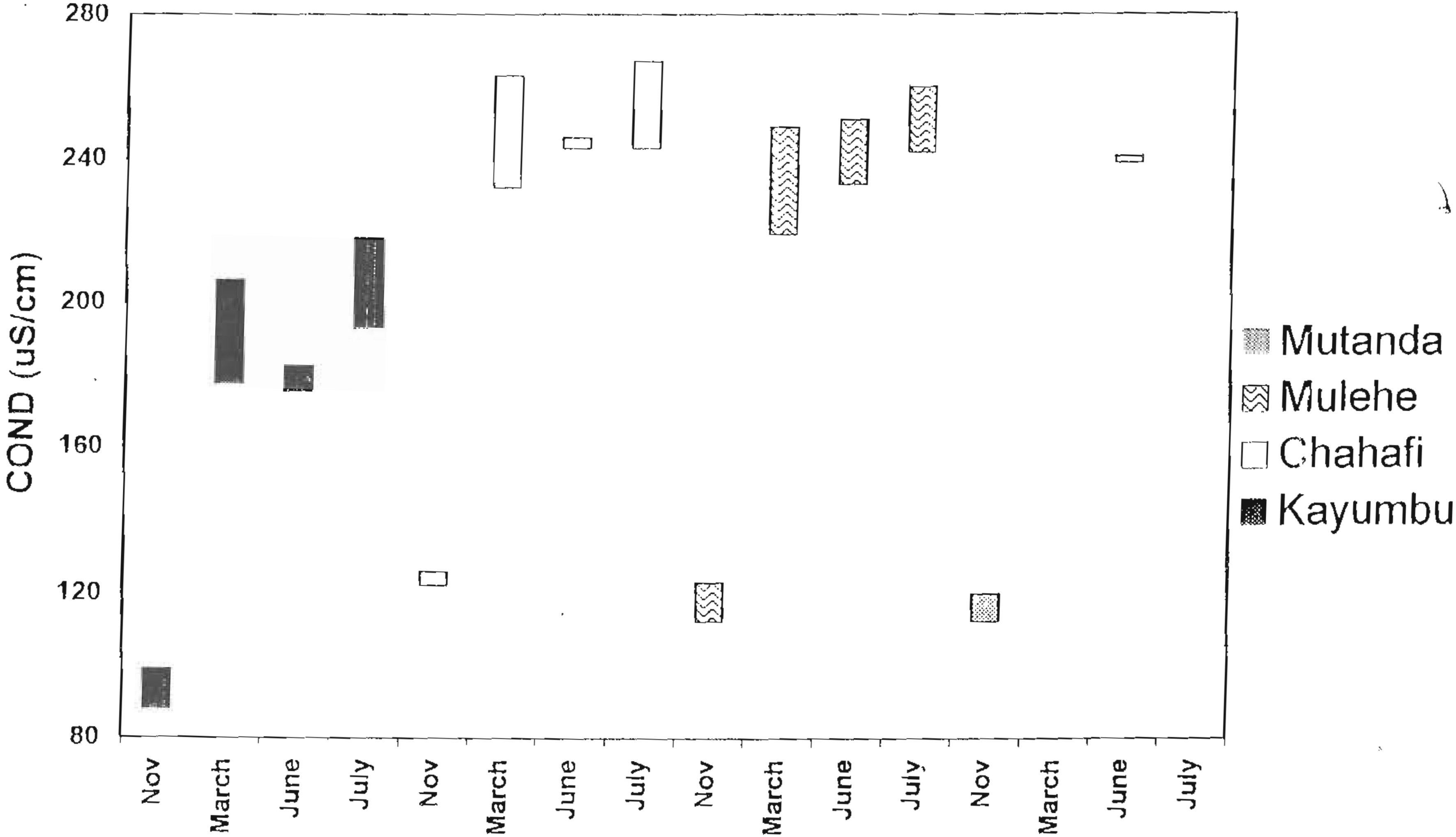


Figure 3: Conductivity (uS/cm) for Kisoro Minor Lakes
Period: Nov 98 - July 99

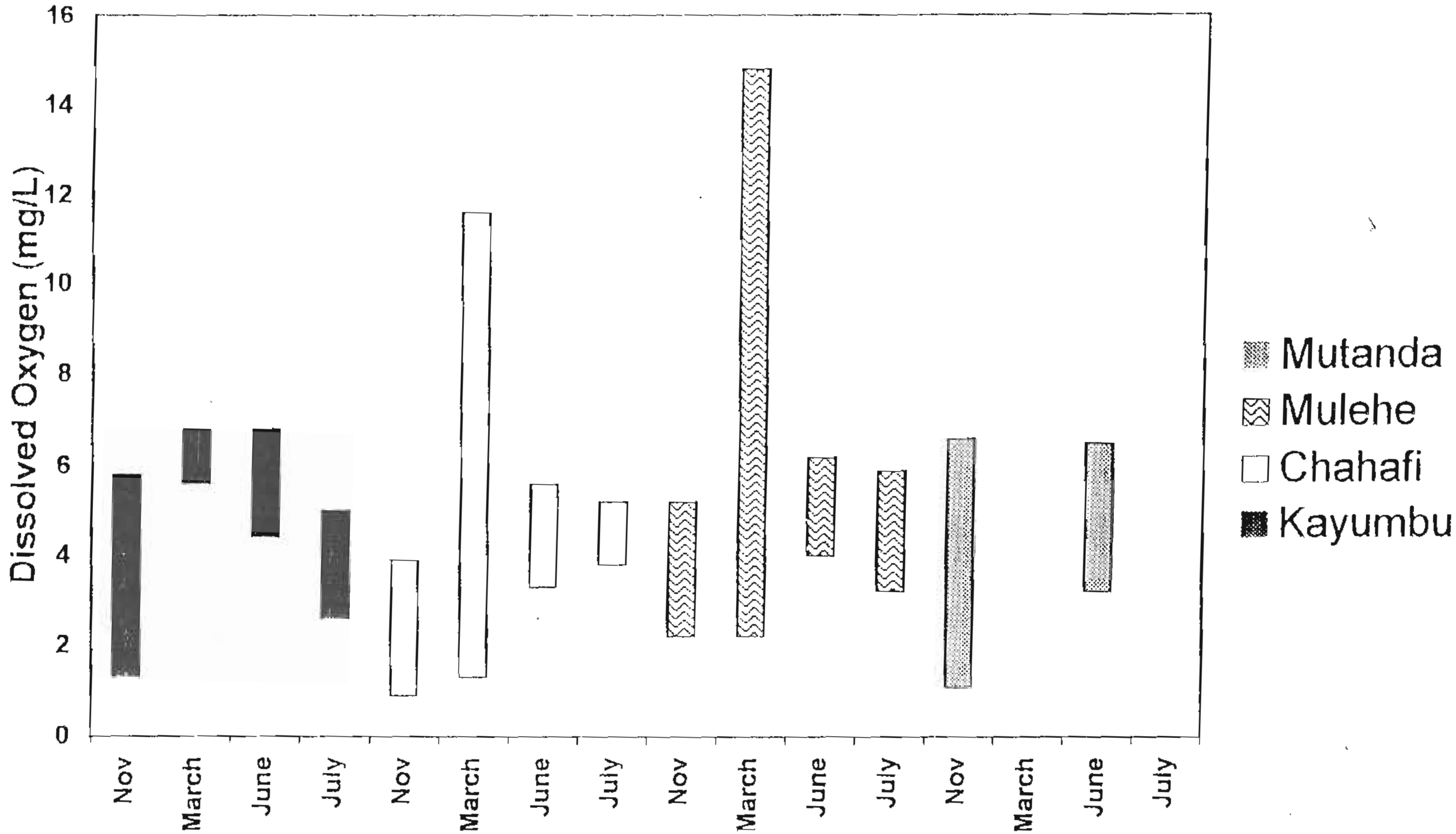


Figure 4: Dissolved Oxygen Conc. (mg/L) for Kisoro Minor Lakes
Period: Nov 98 - July 99

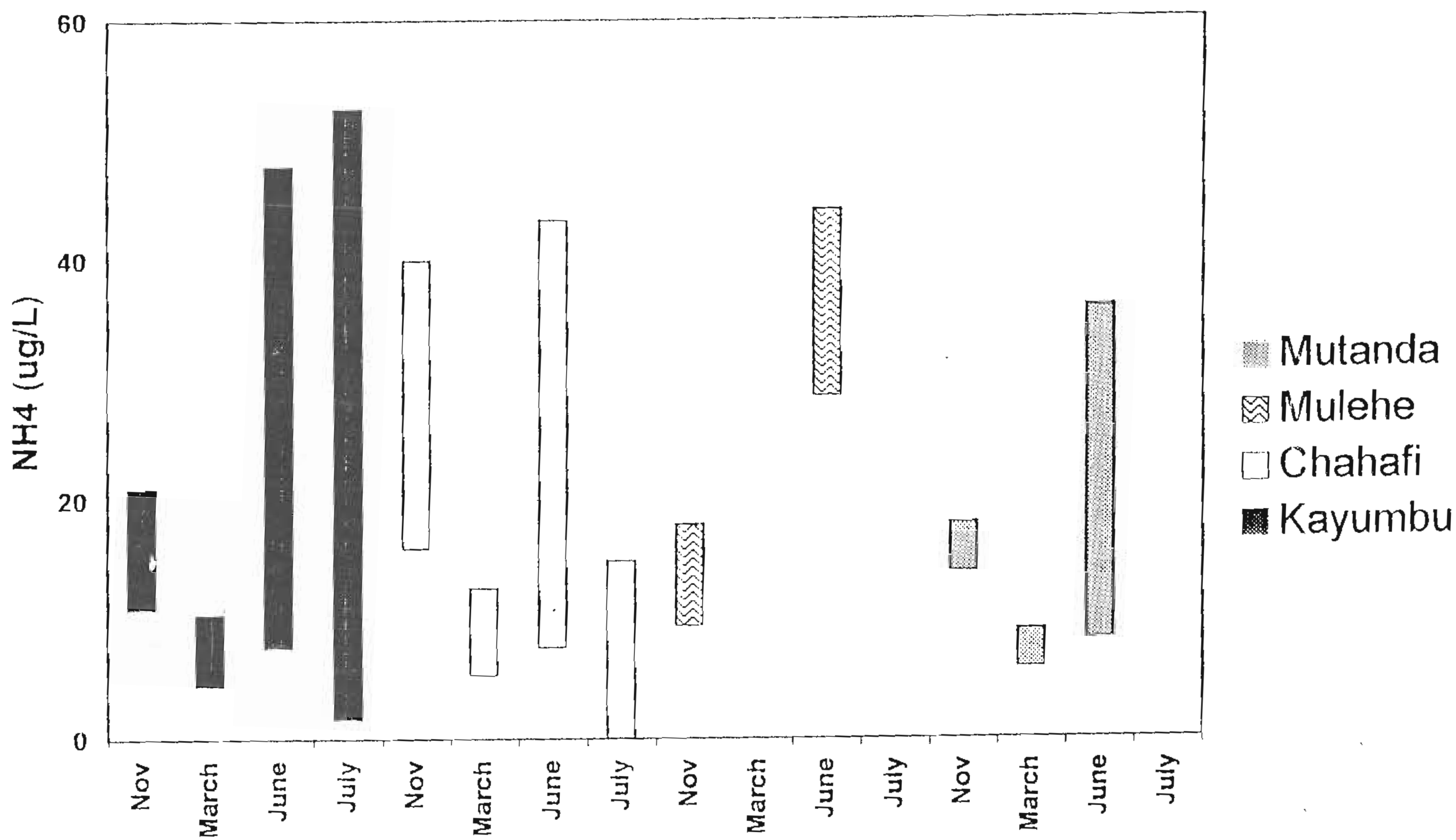


Figure 5: Ammonia Conc. (ug/L) for Kisoro Minor Lakes
Period: Nov 98 - July 99

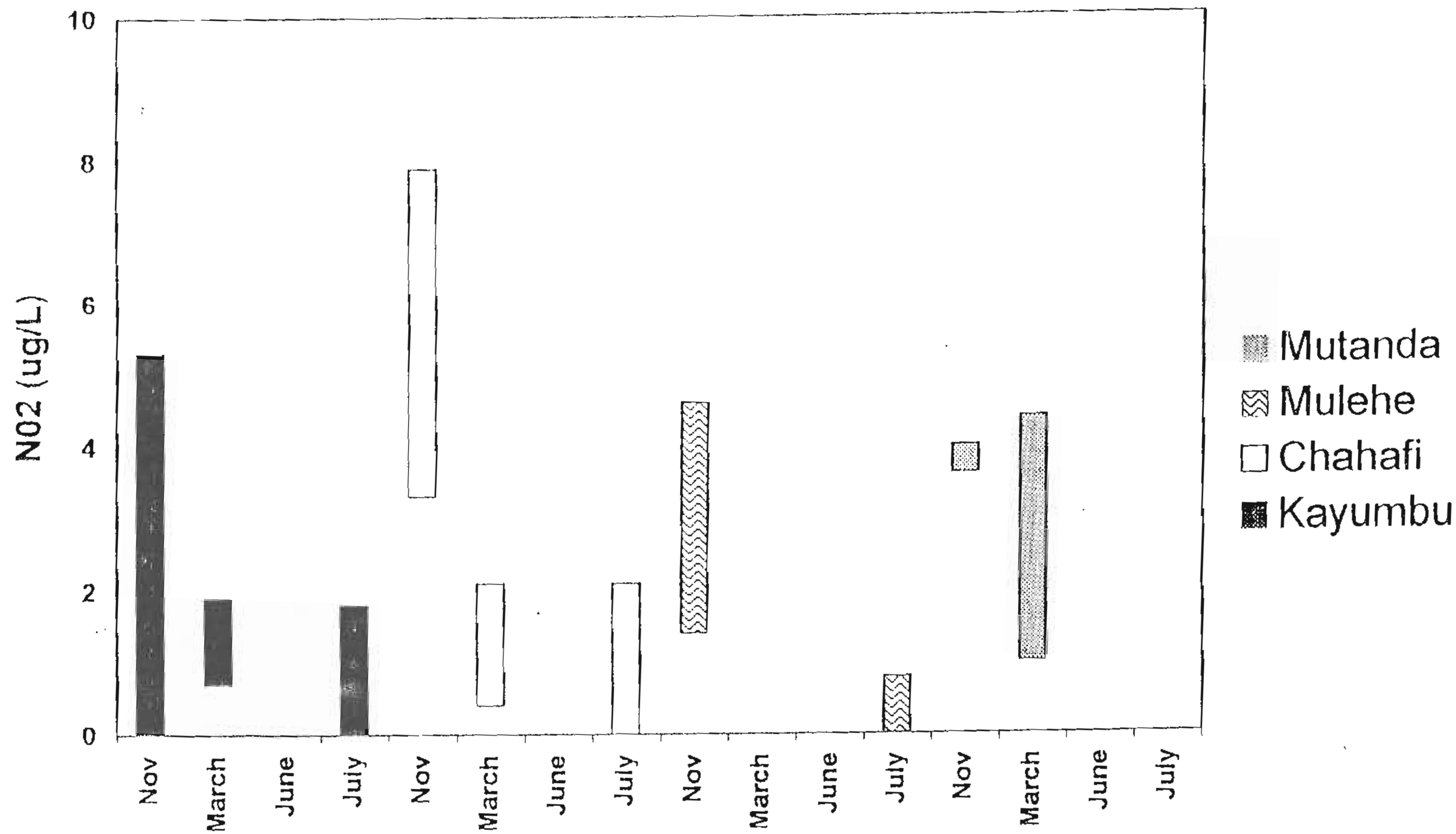


Figure 6: Nitrite Conc. (ug/L) Kisoro Minor Lakes
Period: Nov 98 - July 99

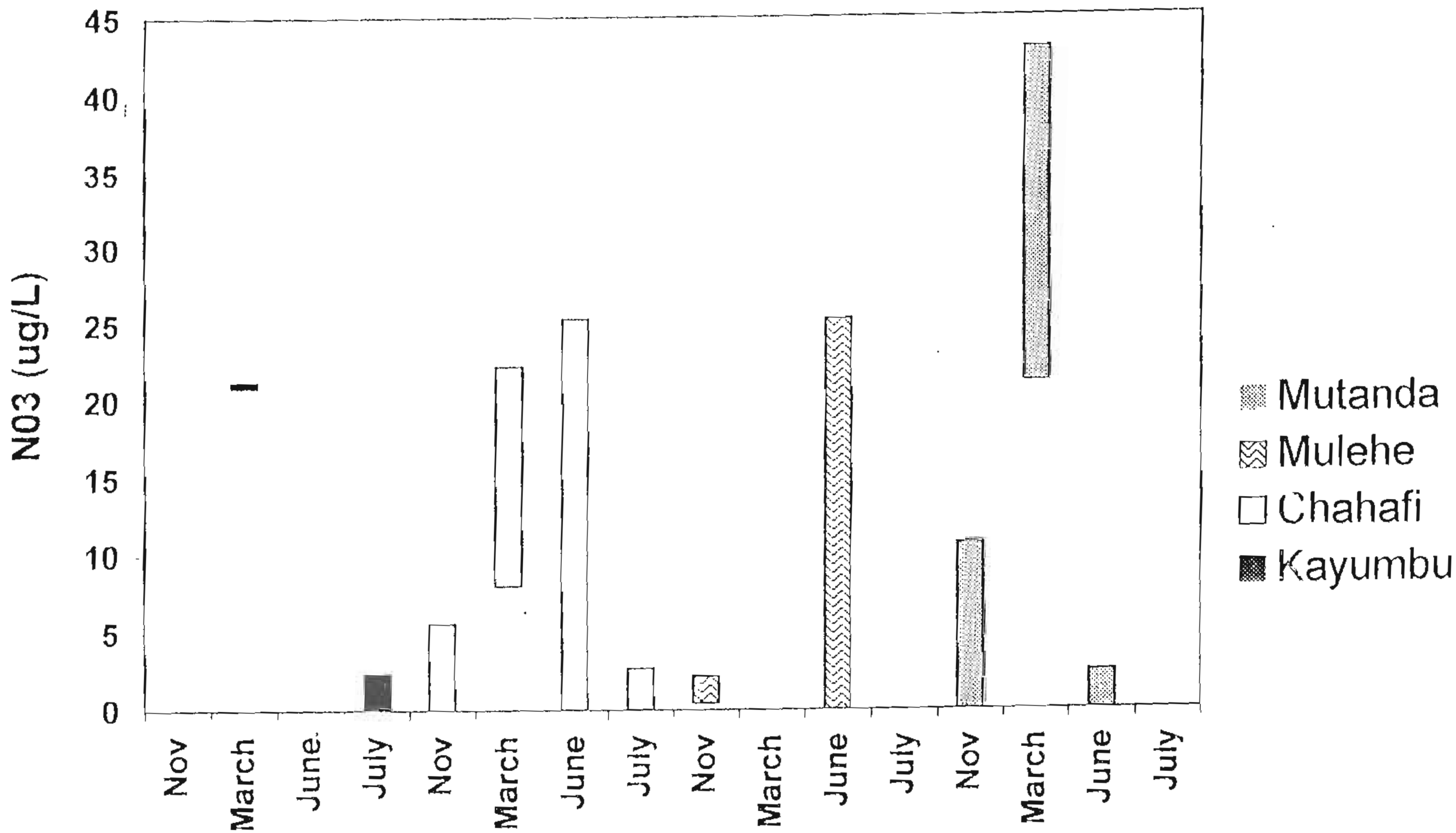


Figure 7: Nitrate (ug/L) for Kisoro Minor Lakes
Period: Nov 98 - July 99

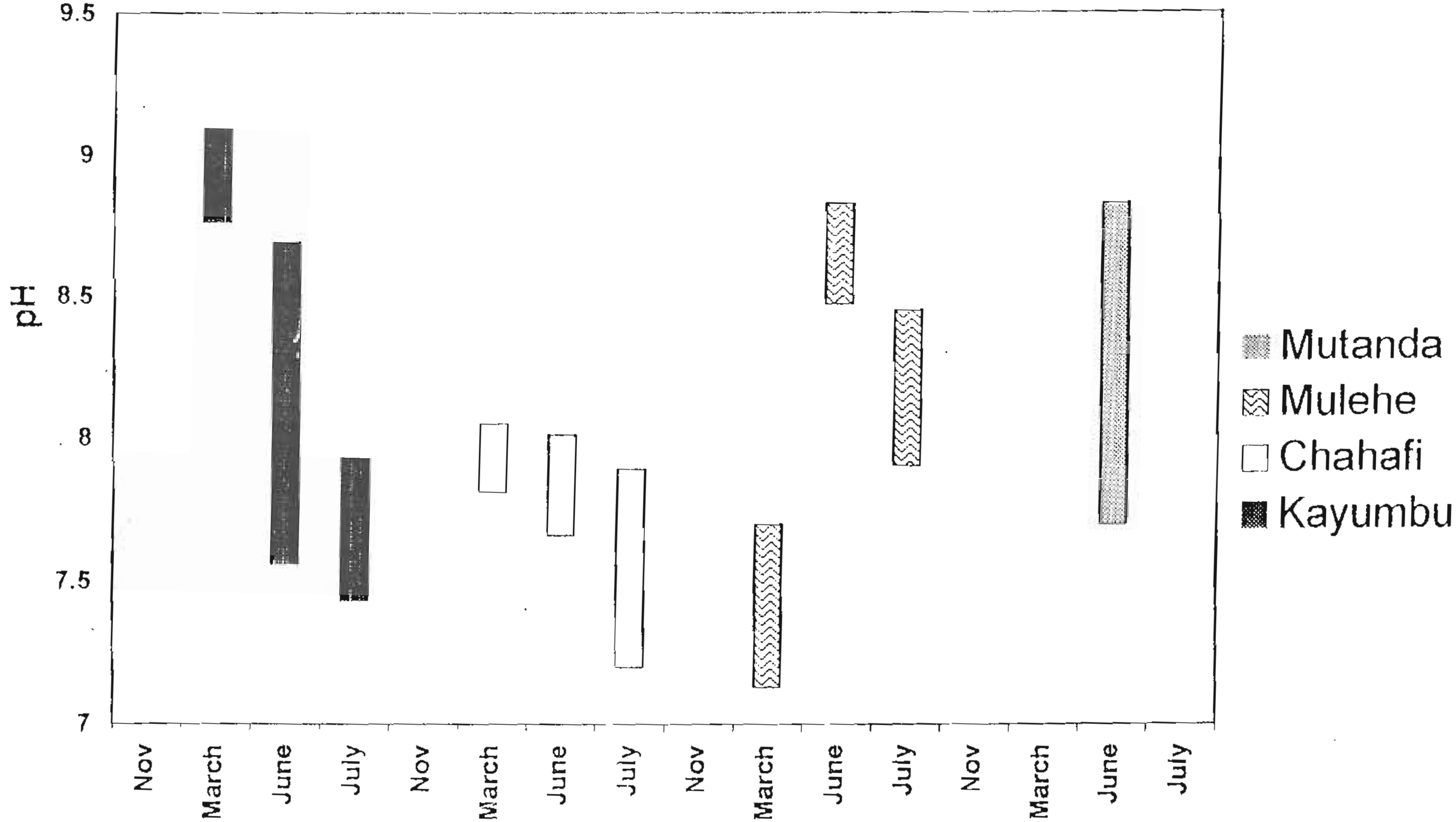


Figure 8: pH Levels for Kisoro Minor Lakes
Period: Nov 98 - July 99

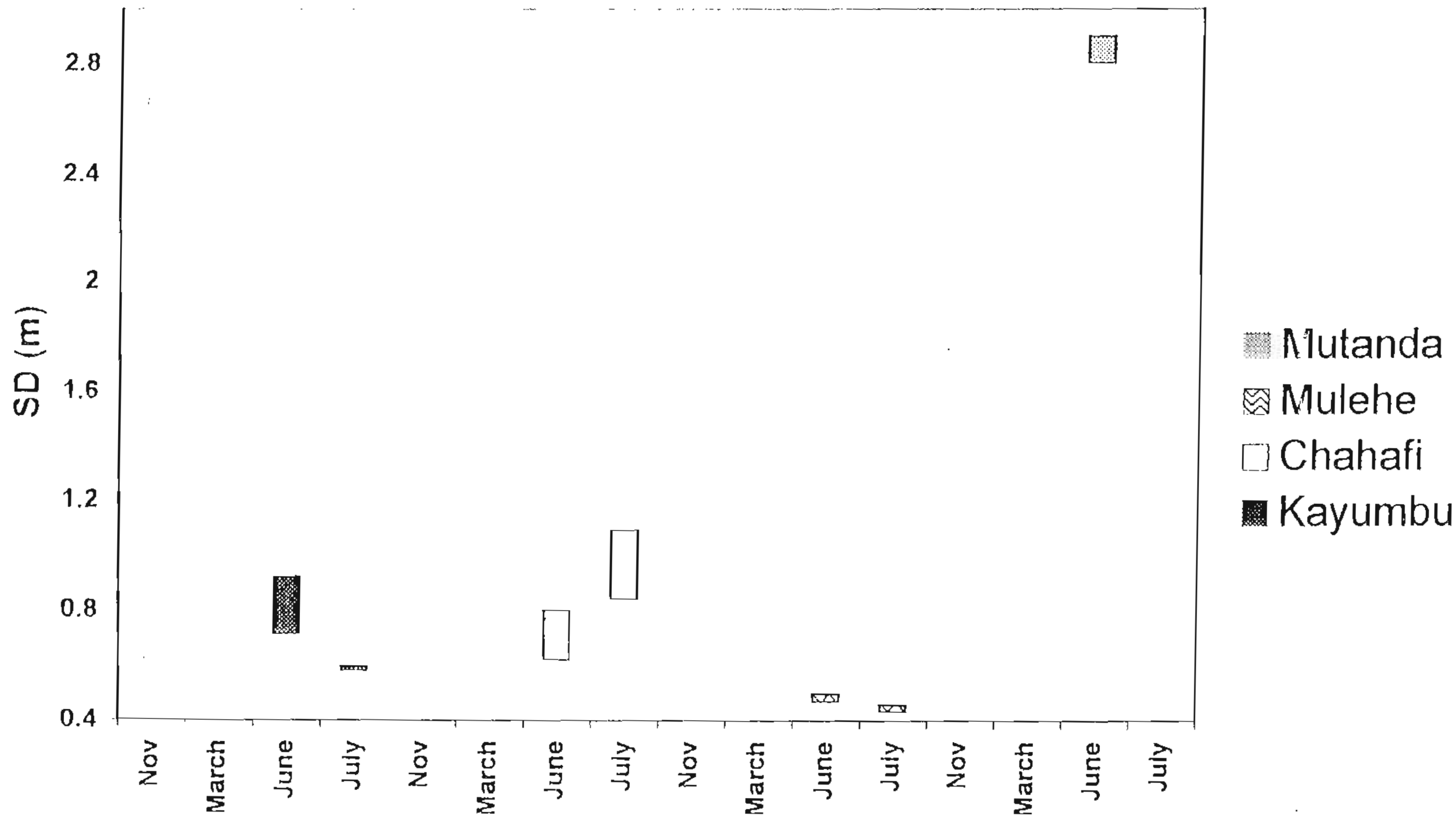


Figure 9: Secchi Depth (m) for Kisoro Minor Lakes
Period: Nov 98 - July 99

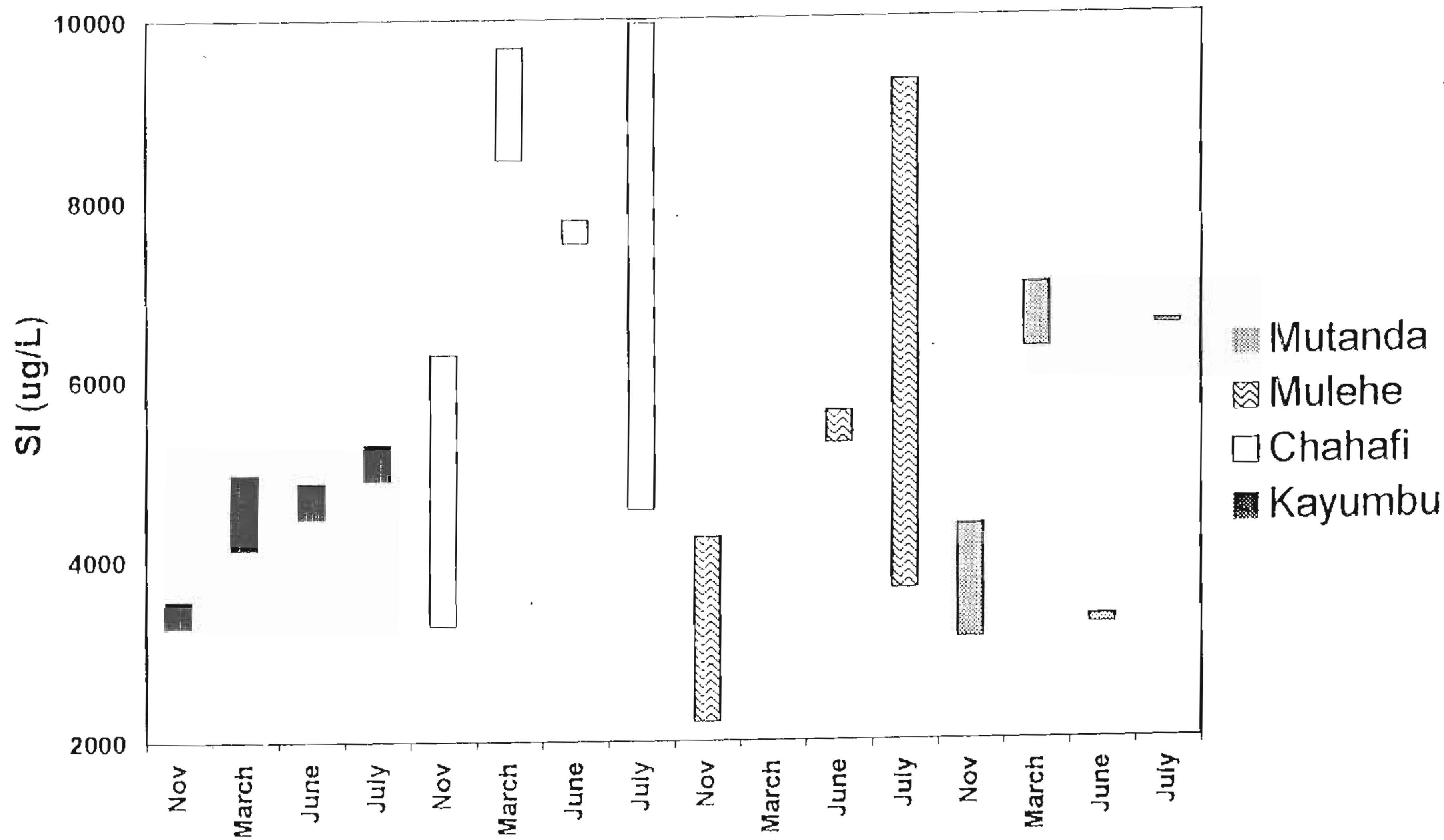


Figure 10: Silica Conc. (ug/L) for Kisoro Minor Lakes
Period: Nov 98 - July 99

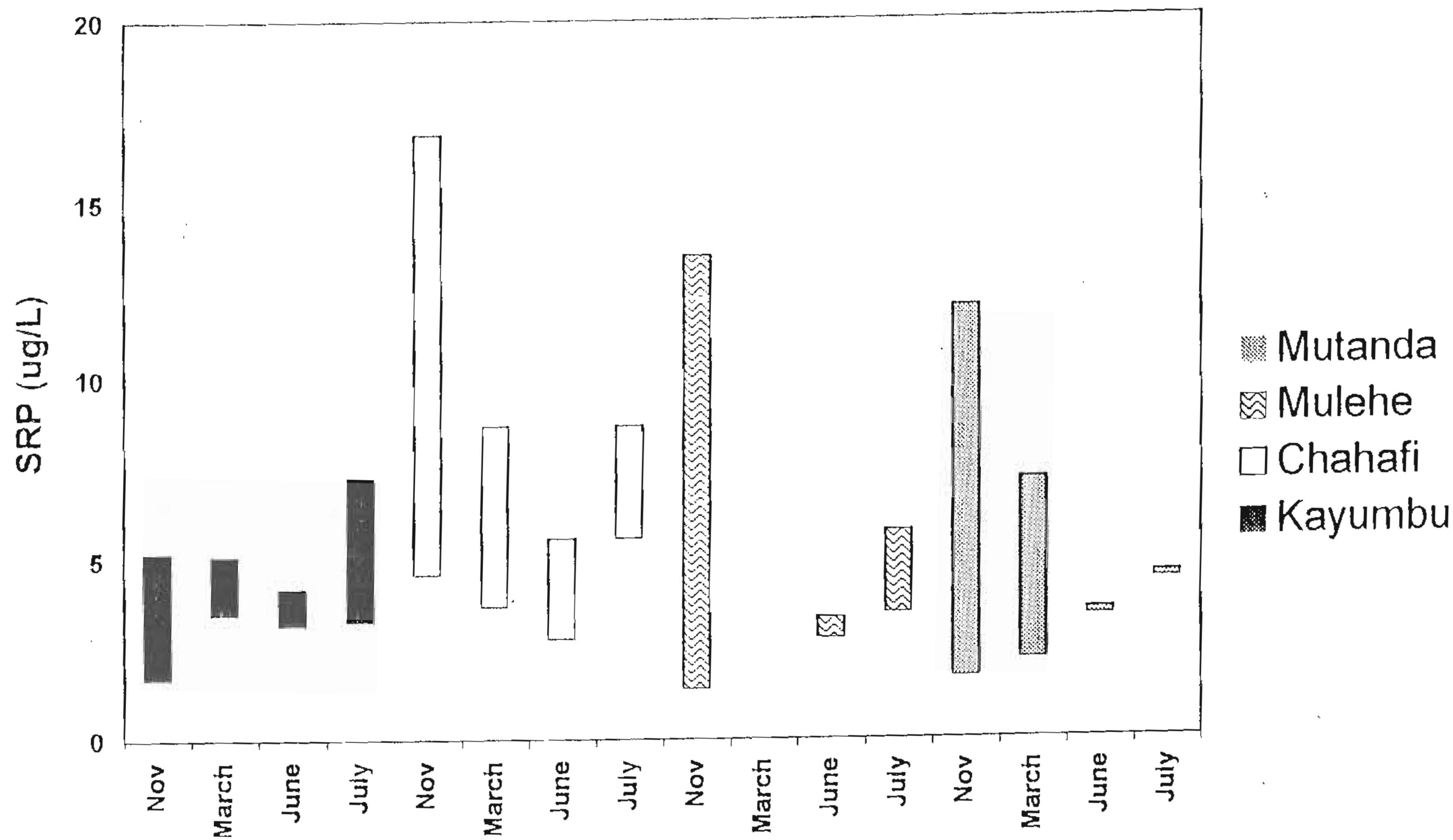


Figure 11: Soluble Reactive Phosphorous Conc. for Kisoro Minor Lakes Period: Nov 98 - July 99

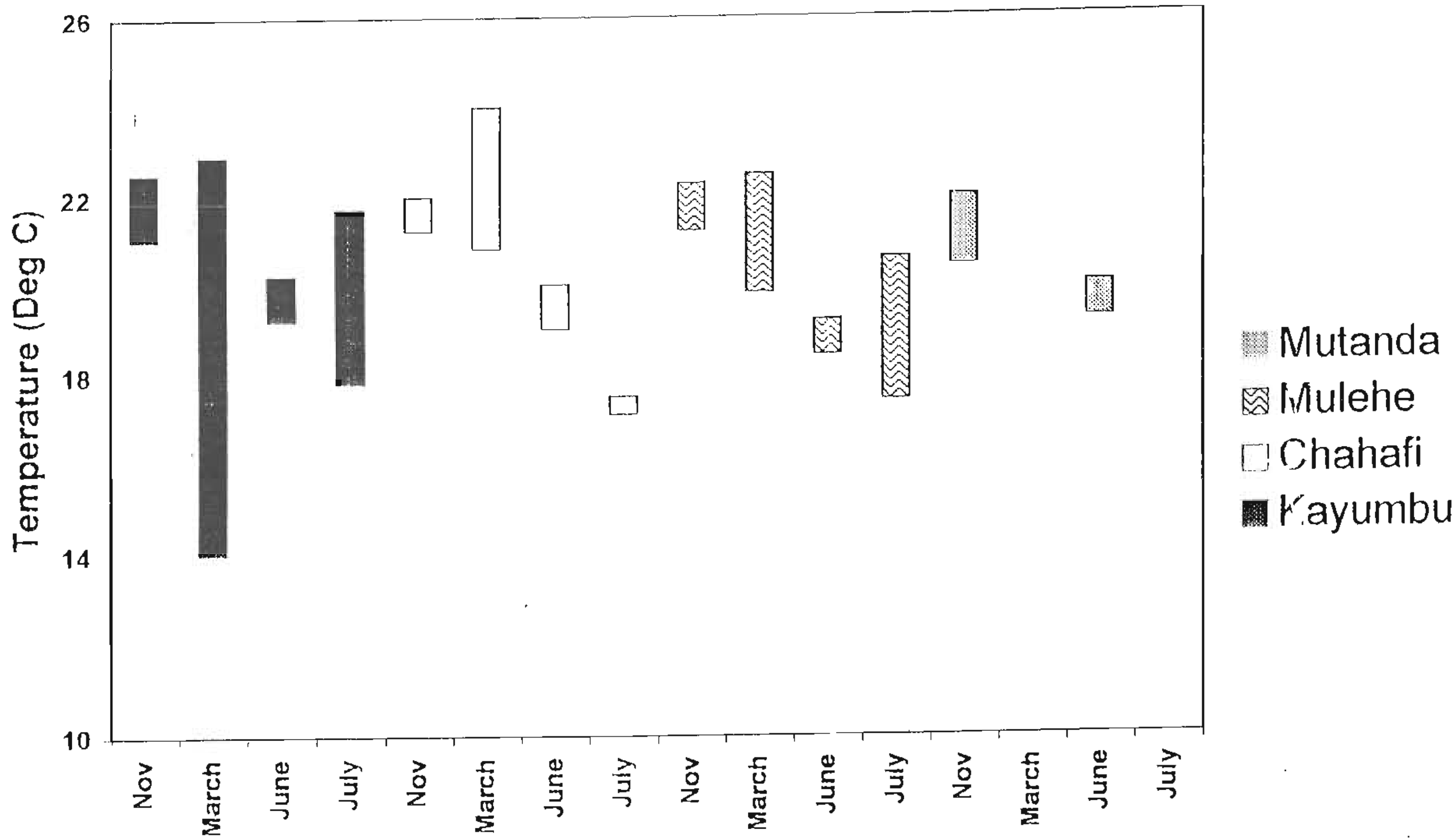


Figure 12: Temperature Deg (C) Kisoro Minor Lakes
Period: Nov 98 - July 99

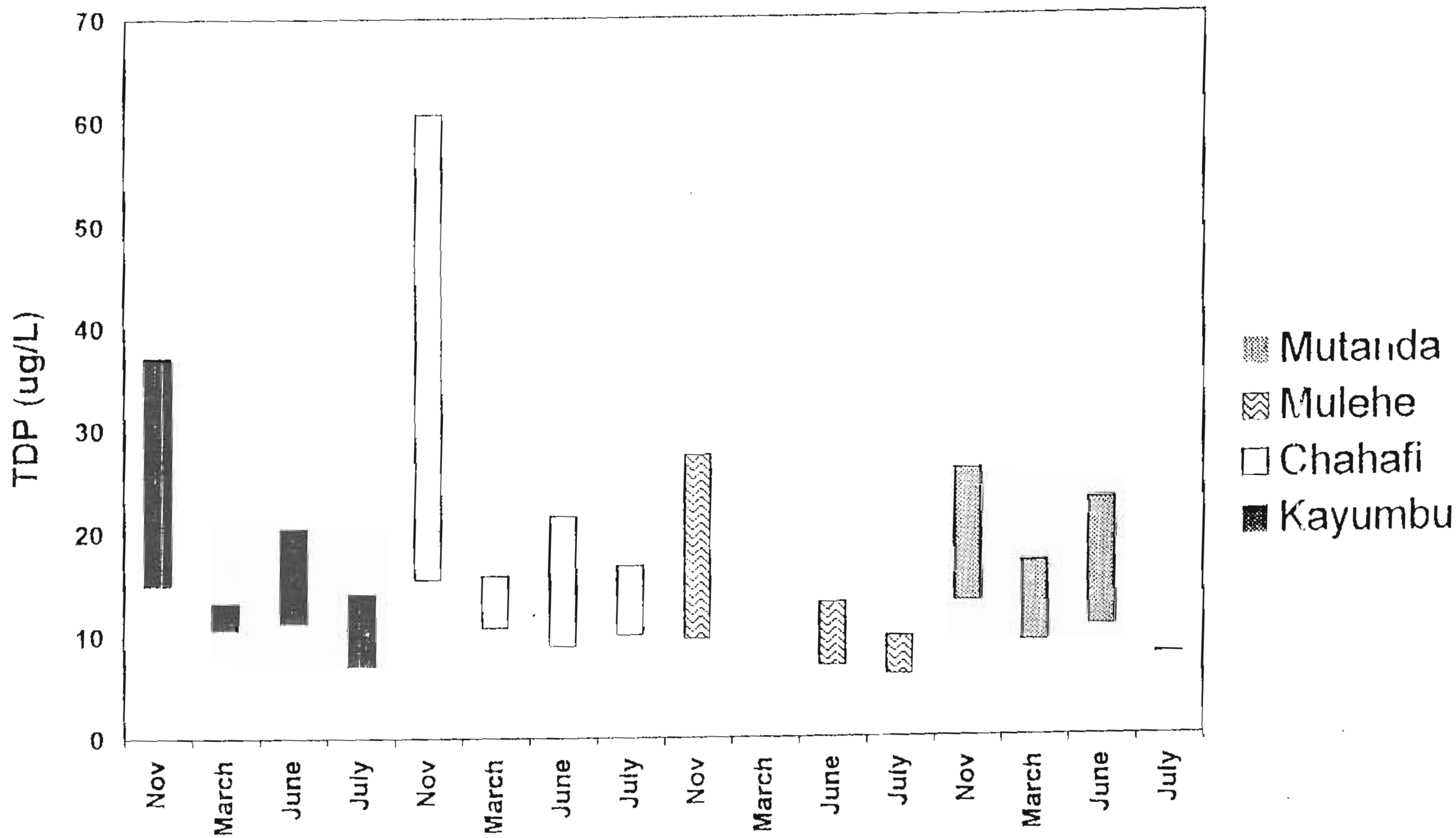


Figure 13: Total Dissolved Phosphorous Conc. (ug/L) for Kisoro Minor Lakes Period: Nov 98 - July 99

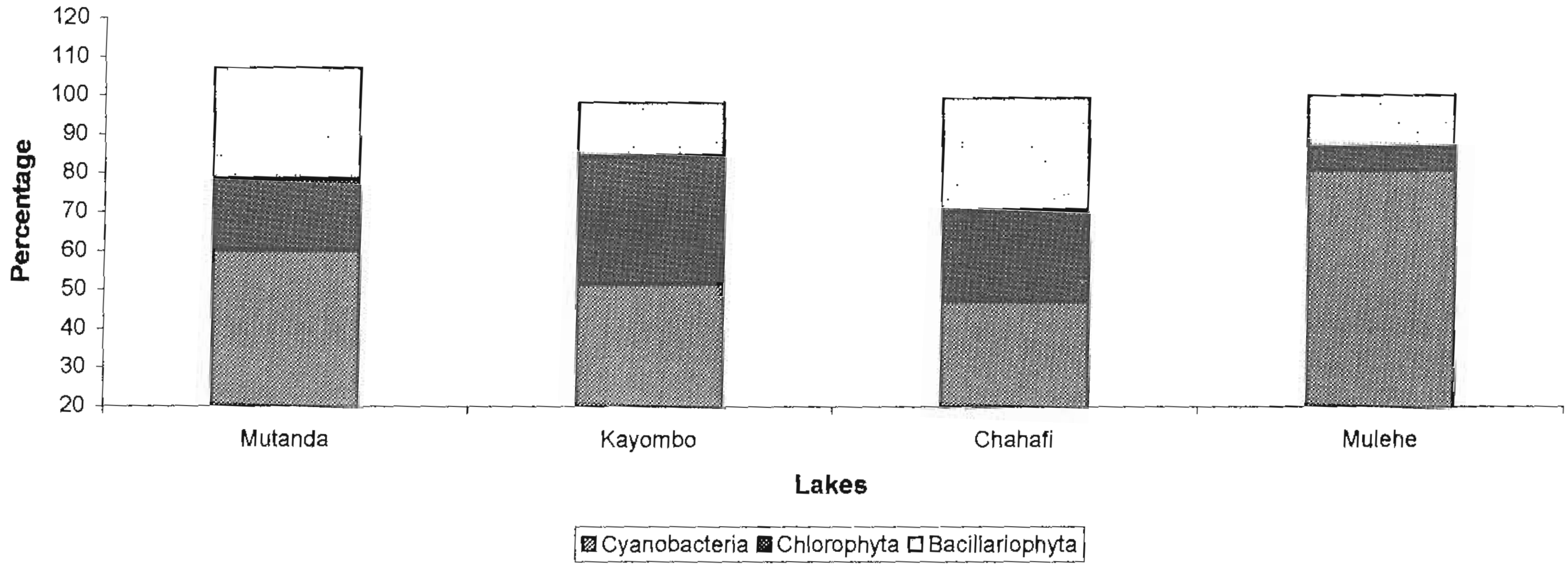


Fig. 14 The relative imporntance of the three major phytoplankton groups (Cyanobacteria, Chlorophyta, Bacillariophyta) expressed in mean percentage abundunces.